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(54) **MOTOR ROTOR AND TURBOCHARGER**

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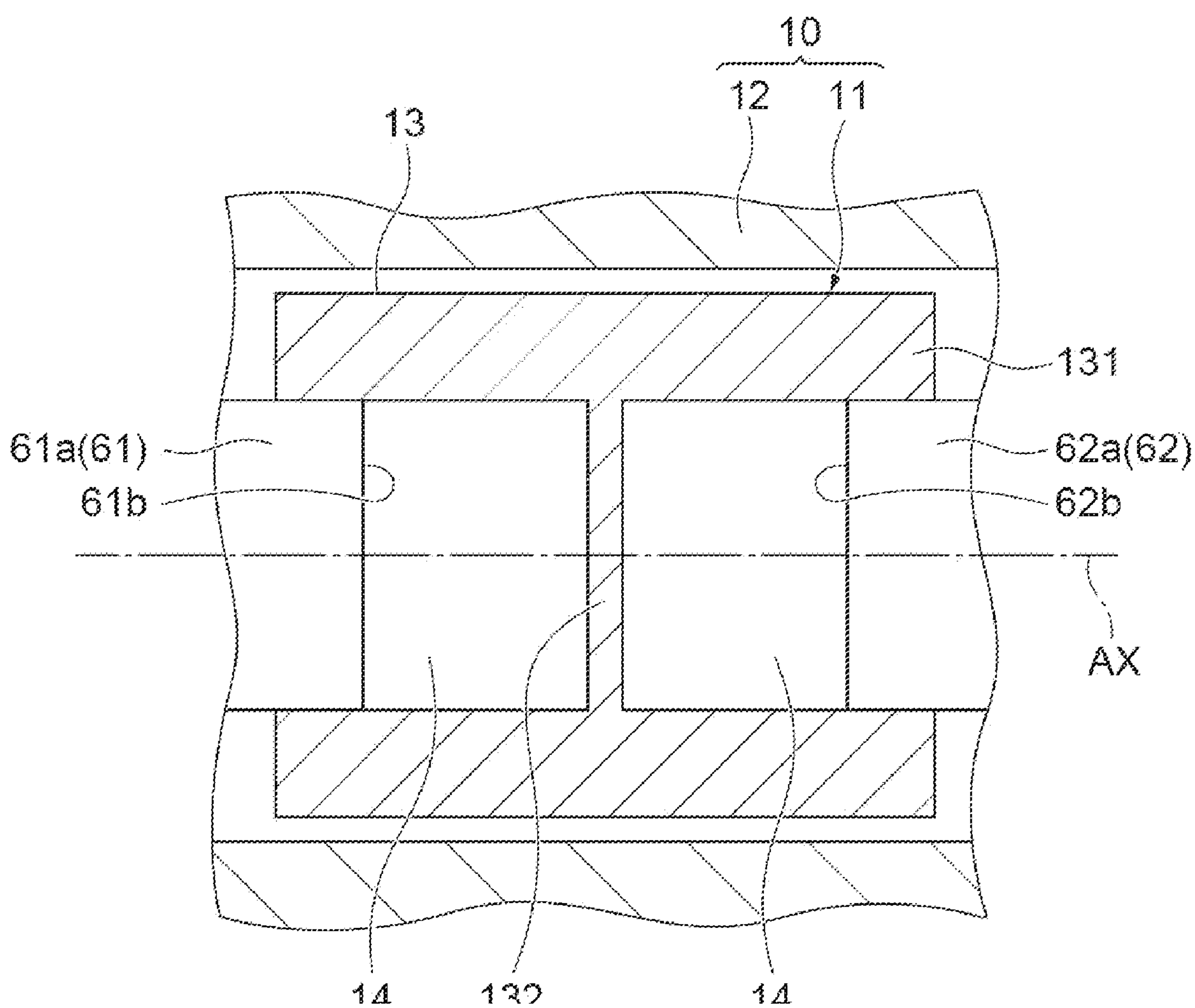
(57) **ABSTRACT**

A motor rotor **11** includes: a holding portion **131** having a tubular shape, a first shaft **61** inserted into one side of the holding portion **131**, a second shaft **62** inserted into the other side of the holding portion **131**, a permanent magnet **14** provided between the first shaft **61** and the second shaft **62** inside the holding portion **131**, and a partition wall portion **132** provided between the first shaft **61** and the second shaft **62** inside the holding portion **131**. The partition wall portion **132** forms a rigid body, together with the holding portion **131**, the first shaft **61**, and the second shaft **62**.



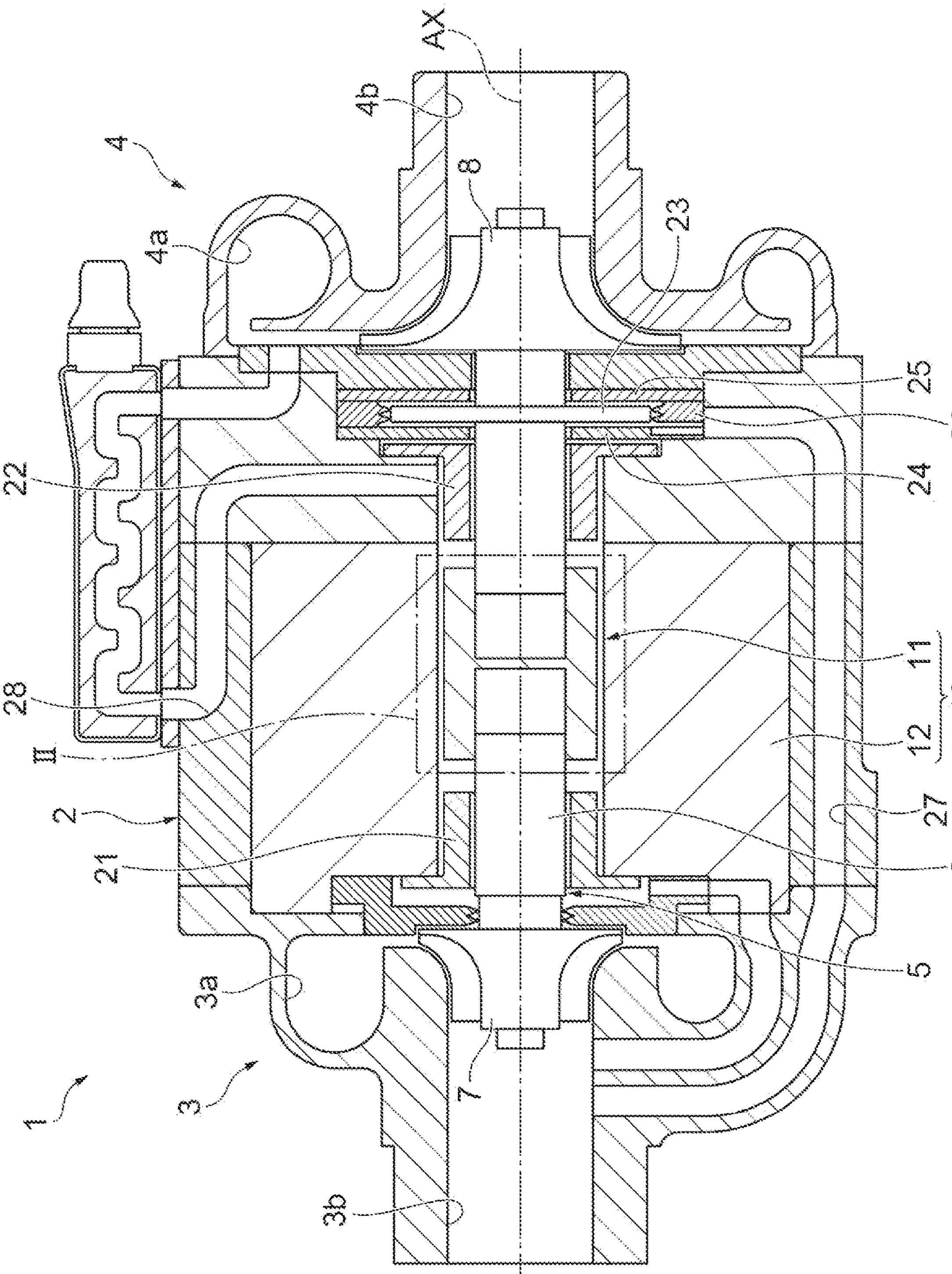


Fig.1

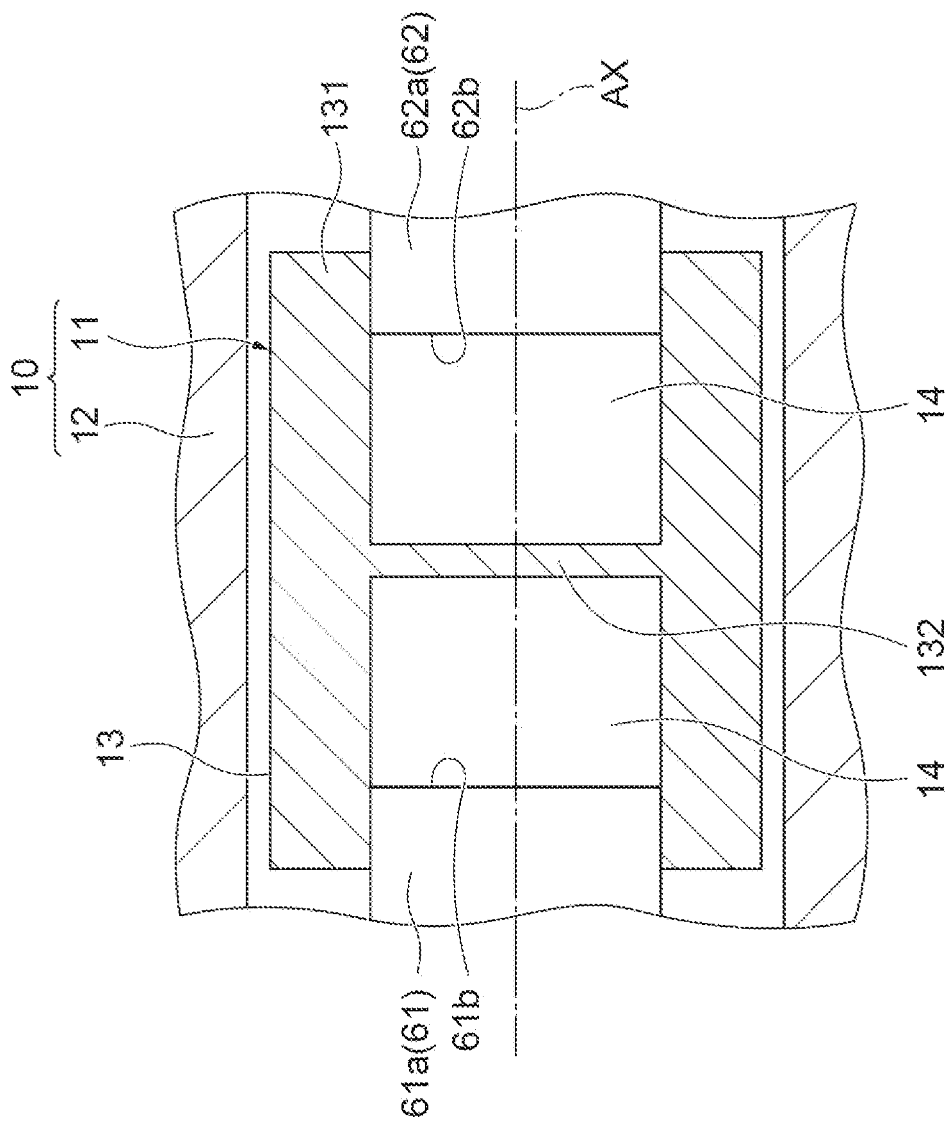


Fig.2

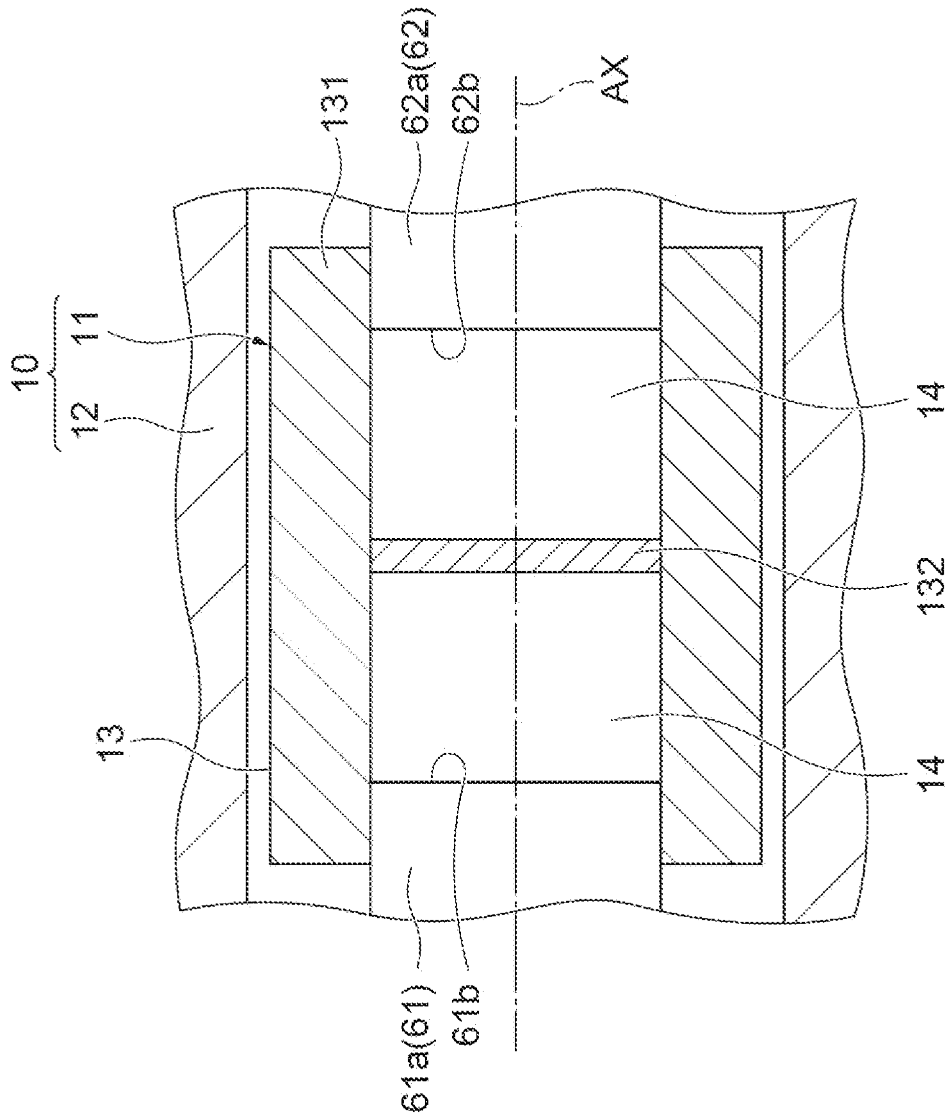


Fig.3

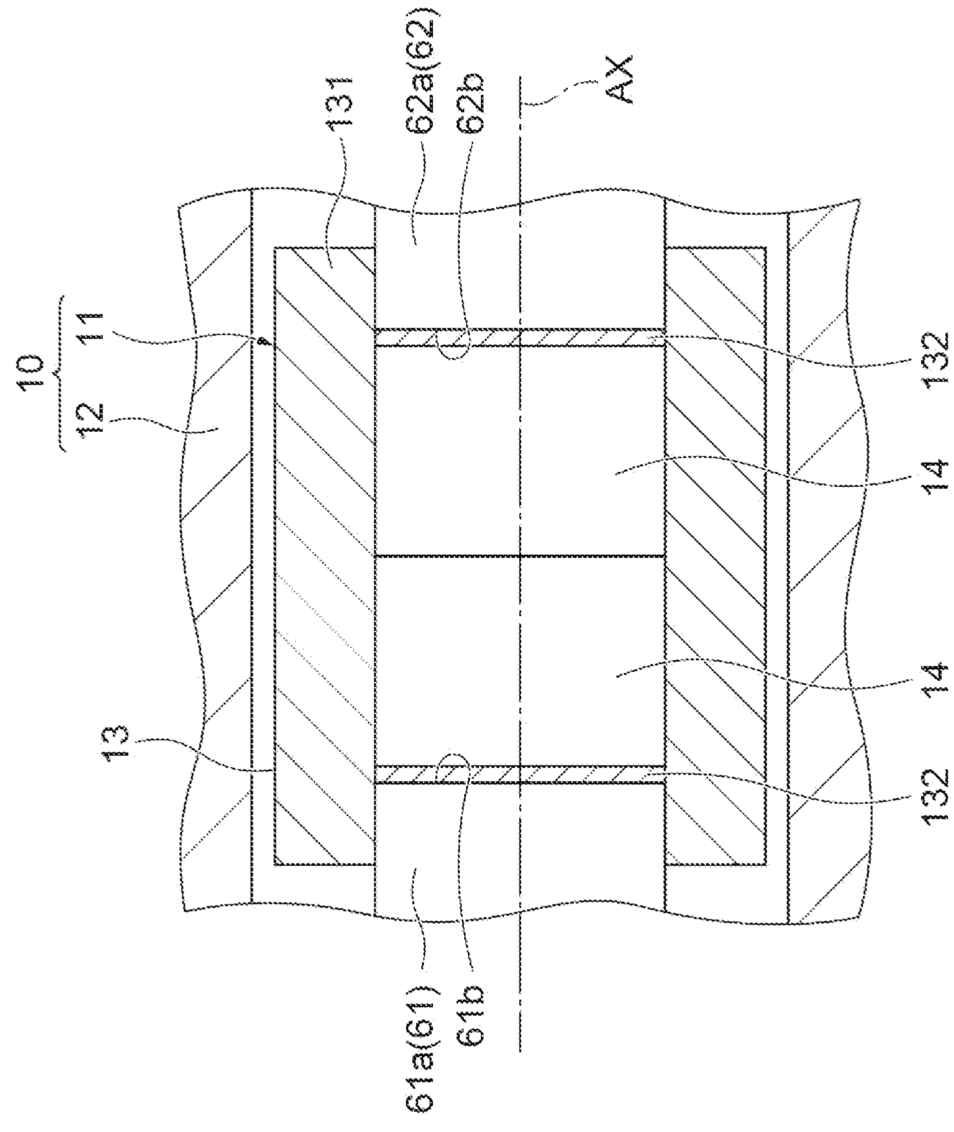


Fig.4

MOTOR ROTOR AND TURBOCHARGER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of PCT Application No. PCT/JP2022/007645, filed on Feb. 24, 2022, which claims the benefit of priority from Japanese Patent Application No. 2021-052829, filed on Mar. 26, 2021. The entire contents of the above listed PCT and priority applications are incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to a motor rotor and a turbocharger.

[0003] An electric turbocharger disclosed in Japanese Unexamined Patent Publication No. 2014-50133 is known as a technique related to a motor rotor. The motor rotor disclosed in Patent Literature 1 includes a shaft, a magnet provided around the shaft, and a holding portion having a tubular shape and covering an outer peripheral surface of the magnet. The holding portion applies a compressive load to the magnet such that the magnet does not detach from the shaft even in a situation where a large centrifugal force acts at the maximum rotation speed.

[0004] In the motor rotor described above, miniaturization may be required. In order to realize the miniaturization of the motor rotor, for example, a configuration can be considered in which the shaft is divided into two parts inside the holding portion and the magnet is disposed between the two shafts. However, in such a case, there is a risk that the rigidity of the motor rotor decreases.

[0005] Therefore, an object of the present disclosure is to provide a motor rotor and a turbocharger capable of suppressing a decrease in rigidity.

SUMMARY

[0006] According to one aspect of the present disclosure, a motor rotor includes: a holding portion having a tubular shape, a first shaft inserted into one side of the holding portion, a second shaft inserted into the other side of the holding portion, a magnet provided between the first shaft and the second shaft inside the holding portion, and a partition wall portion provided between the first shaft and the second shaft inside the holding portion. The partition wall portion forms a rigid body, together with the holding portion, the first shaft, and the second shaft.

[0007] According to one aspect of the present disclosure, a turbocharger includes the motor rotor described above. The motor rotor includes a compressor impeller provided on a side of the second shaft which is opposite from the first shaft.

[0008] According to the present disclosure, it is possible to provide the motor rotor and the turbocharger capable of suppressing a decrease in rigidity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a cross-sectional view of a turbocharger according to one embodiment.

[0010] FIG. **2** is an enlarged view of a portion II in FIG. **1**.

[0011] FIG. **3** is an enlarged view of a turbocharger according to a modification example.

[0012] FIG. **4** is an enlarged view of a turbocharger according to a modification example.

DETAILED DESCRIPTION

[0013] According to one aspect of the present disclosure, a motor rotor includes: a holding portion having a tubular shape, a first shaft inserted into one side of the holding portion, a second shaft inserted into the other side of the holding portion, a magnet provided between the first shaft and the second shaft inside the holding portion, and a partition wall portion provided between the first shaft and the second shaft inside the holding portion. The partition wall portion forms a rigid body, together with the holding portion, the first shaft, and the second shaft.

[0014] In the motor rotor, the first shaft is inserted into the one side of the holding portion, the second shaft is inserted into the other side of the holding portion, and the magnet is provided between the first shaft and the second shaft inside the holding portion. Accordingly, for example, compared to the case where a magnet is disposed on an outer periphery of a shaft, miniaturization of the motor rotor can be achieved. Moreover, the partition wall portion is provided between the first shaft and the second shaft, and the partition wall portion forms a rigid body, together with the holding portion, the first shaft, and the second shaft. Accordingly, a decrease in the rigidity of the motor rotor can be suppressed.

[0015] The magnet may be each of a plurality of magnets. The partition wall portion may be provided between the plurality of magnets. Accordingly, the degree of freedom in designing each of the plurality of magnets and the partition wall portion can be improved.

[0016] The partition wall portion may be provided between at least one of the first shaft and the second shaft, and the magnet. Accordingly, a decrease in the rigidity of the motor rotor can be suppressed with a simple configuration.

[0017] A rigidity of the partition wall portion may be larger than a rigidity of the magnet. Accordingly, a decrease in the rigidity of the motor rotor can be reliably suppressed.

[0018] Each of the holding portion and the partition wall portion may be a part of the holding member. Accordingly, the cost can be reduced and the productivity can be improved by reducing the number of components.

[0019] The partition wall portion may be formed separately from the holding portion. Accordingly, the degree of freedom in designing each of the holding portion and the partition wall portion can be improved.

[0020] According to one aspect of the present disclosure, a turbocharger includes the motor rotor. The motor rotor includes a compressor impeller provided on a side of the second shaft which is opposite from the first shaft.

[0021] According to the turbocharger, as described above, a decrease in the rigidity of the motor rotor can be suppressed.

[0022] Hereinafter, an embodiment of the present disclosure will be described in detail with reference to the drawings. It should be noted that in each of the drawings, the same or equivalent portions are denoted by the same reference signs, and duplicate descriptions will be omitted.

[0023] As shown in FIG. **1**, a turbocharger **1** is an electric turbocharger. The turbocharger **1** is applied to, for example, internal combustion engines for ships or vehicles. The turbocharger **1** includes an electric motor **10**, a motor housing **2**, a turbine housing **3**, and a compressor housing **4**.

The electric motor **10** includes a rotating body **5**. The rotating body **5** includes a shaft **6**, a turbine impeller **7**, and a compressor impeller **8**.

[0024] The shaft **6** has, for example, a columnar shape. The turbine impeller **7** is provided at one end of the shaft **6**. The compressor impeller **8** is provided at the other end of the shaft **6**. The motor housing **2** is provided between the turbine impeller **7** and the compressor impeller **8**. The rotating body **5** is rotatably supported by the motor housing **2**. Specifically, the shaft **6** is accommodated in the motor housing **2**. A pair of bearings **21** and **22** are provided between the shaft **6** and the motor housing **2**. The bearings **21** and **22** support the shaft **6** in a radial direction at both end portions of the shaft **6**.

[0025] The shaft **6** includes a thrust collar **23** provided on a compressor impeller **8** side. The thrust collar **23** protrudes in a radial direction of the shaft **6**. The thrust collar **23** has, for example, a disk shape. A pair of air bearings **24** and **25** are provided on both sides of the thrust collar **23** in an axial direction of the shaft **6**. A spacer **26** surrounding the thrust collar **23** is provided between the pair of air bearings **24** and **25**.

[0026] The pair of air bearings **24** and **25** and the spacer **26** are integrally fastened together by a plurality of fastening bolts. The air bearings **24** and **25** and the spacer **26** that are integrated are fixed inside the motor housing **2**. The air bearings **24** and **25** and the spacer **26** define an accommodation space in which the thrust collar **23** is accommodated. The accommodation space supports the shaft **6** in a thrust direction. The thrust collar **23** is rotatable in the state of non-contact with the air bearings **24** and **25** and the spacer **26** within the accommodation space.

[0027] The turbine housing **3** accommodates the turbine impeller **7**. The turbine housing **3** forms a turbine, together with the turbine impeller **7**. The turbine housing **3** has a scroll passage **3***a*. The scroll passage **3***a* extends around the turbine impeller **7** in a circumferential direction centered on an axis AX of the shaft **6** (hereinafter, simply referred to as the “circumferential direction”).

[0028] The turbine housing **3** has an inlet and an outlet **3***b*. Exhaust gas discharged from an internal combustion engine flows into the turbine housing **3** through the inlet. The exhaust gas that has flowed into the turbine housing **3** flows into the turbine impeller **7** through the scroll passage **3***a*. Then, the exhaust gas rotates the turbine impeller **7**. Thereafter, the exhaust gas flows to the outside of the turbine housing **3** through the outlet **3***b*.

[0029] The compressor housing **4** accommodates the compressor impeller **8**. The compressor housing **4** forms a compressor, together with the compressor impeller **8**. The compressor housing **4** has a scroll passage **4***a*. The scroll passage **4***a* extends around the compressor impeller **8** in the circumferential direction.

[0030] The compressor housing **4** has an inlet port **4***b* and an outlet port. When the turbine impeller **7** rotates, the compressor impeller **8** rotates via the shaft **6**. The rotating compressor impeller **8** suctions outside air through the inlet port **4***b*. The air suctioned by the compressor impeller **8** is compressed by passing through the compressor impeller **8** and the scroll passage **4***a*. The air is discharged from the outlet port as compressed air. The compressed air is supplied to the internal combustion engine.

[0031] An air discharge passage **27** is formed continuously in the motor housing **2** and the turbine housing **3**. The air discharge passage **27** communicates the accommodation space defined by the air bearings **24** and **25** and the spacer **26** with the outlet **3***b* of the turbine housing **3**. During operation of the turbocharger **1**, air in the accommodation space is discharged little by little to the outside through the air discharge passage **27** and the outlet **3***b*.

[0032] A cooling air passage **28** is formed in the motor housing **2**. The cooling air passage **28** communicates a space, in which the bearings **21** and **22** are provided, with the compressor housing **4**. Some of air flowing through the compressor housing **4** flows into the space, in which the bearings **21** and **22** are provided, through the cooling air passage **28**. Accordingly, the bearings **21** and **22** and the like are cooled.

[0033] Next, the electric motor **10** will be described. The electric motor **10** is, for example, a brushless AC electric motor. As shown in FIGS. **1** and **2**, the electric motor **10** includes a motor rotor **11** which is a rotor, and a motor stator **12** which is a stator. The motor rotor **11** corresponds to the rotating body **5**. The motor rotor **11** includes a first shaft **61**, a second shaft **62**, a holding member **13**, a plurality of permanent magnets **14**, the turbine impeller **7**, and the compressor impeller **8**.

[0034] Each of the first shaft **61** and the second shaft **62** is a part of the shaft **6**. Namely, the shaft **6** is divided into two parts: the first shaft **61** and the second shaft **62**. Each of the first shaft **61** and the second shaft **62** has, for example, a columnar shape. The turbine impeller **7** is provided on a side of the first shaft **61** which is opposite from the second shaft **62**. The compressor impeller **8** is provided on a side of the second shaft **62** which is opposite from the first shaft **61**.

[0035] The holding member **13** is provided between the pair of bearings **21** and **22** in the axial direction of the shaft **6**. The holding member **13** includes a holding portion **131**. The holding portion **131** has, for example, a tubular shape. In the present embodiment, the holding portion **131** has a cylindrical shape. The holding portion **131** may be called an “armour ring” or the like. An end portion **61***a* of the first shaft **61** on a side which is opposite from the turbine impeller **7** is inserted into one side of the holding portion **131**. The end portion **61***a* of the first shaft **61** is press-fitted into the one side of the holding portion **131**. An end portion **62***a* of the second shaft **62** on a side which is opposite from the compressor impeller **8** is inserted into the other side of the holding portion **131**. The end portion **62***a* of the second shaft **62** is press-fitted into the other side of the holding portion **131**.

[0036] An end surface **61***b* of the first shaft **61** on a side which is opposite from the turbine impeller **7** and an end surface **62***b* of the second shaft **62** on a side which is opposite from the compressor impeller **8** are separated from each other. In the present embodiment, the motor rotor **11** includes two permanent magnets **14**. Each of the permanent magnets **14** has, for example, a columnar shape.

[0037] Each of the permanent magnets **14** is provided between the first shaft **61** and the second shaft **62** inside the holding portion **131**. Each of the permanent magnets **14** is press-fitted into the holding portion **131**. One permanent magnet **14** is in contact with the end surface **61***b* of the first shaft **61**. The other permanent magnet **14** is in contact with the end surface **62***b* of the second shaft **62**. The two permanent magnets **14** are separated from each other. Each of the permanent magnets **14** is, for example, a neodymium (Nd—Fe—B) magnet, a samarium cobalt magnet, or the like.

[0038] The holding member **13** further includes a partition wall portion **132**. The partition wall portion **132** has a plate shape. The partition wall portion **132** is provided between the first shaft **61** and the second shaft **62** inside the holding portion **131**. The partition wall portion **132** is provided between the two permanent magnets **14**. The partition wall portion **132** has the axial direction of the shaft **6** as a thickness direction. Namely, the partition wall portion **132** extends in a plane perpendicular to the axis AX of the shaft **6**. The partition wall portion **132** extends to an inner wall of the holding portion **131**. Namely, the partition wall portion **132** extends from the inner wall of the holding portion **131** in a radial direction of the holding portion **131**. The partition wall portion **132** is located at approximately the center of the holding portion **131** in the axial direction of the shaft **6**.

[0039] The partition wall portion **132** is in contact with each of the permanent magnets **14**. A rigidity of the partition wall portion **132** may be larger than a rigidity of each of the permanent magnets **14**. An elastic modulus of the partition wall portion **132** may be larger than an elastic modulus of each of the permanent magnets **14**. Each of the holding portion **131** and the partition wall portion **132** may be a part of the holding member **13**. Namely, the holding member **13** including the holding portion **131** and the partition wall portion **132** is formed as one component from the same material. The material of the holding member **13** is, for example, metal. The material of the holding member **13** is, for example, non-magnetic metal such as titanium (for example, Ti-6Al-4V).

[0040] The motor rotor **11** is configured as one rigid body with the holding portion **131**, the first shaft **61**, the second shaft **62**, each of the permanent magnets **14**, the partition wall portion **132**, the turbine impeller **7**, and the compressor impeller **8**. Namely, the motor rotor **11** is integrally formed. The partition wall portion **132** suppresses a decrease in the bending rigidity of the motor rotor **11**. For example, the partition wall portion **132** improves the natural frequency (eigenvalue) of the motor rotor **11** compared to the case where the motor rotor **11** does not include the partition wall portion **132**. The natural frequency of the motor rotor **11** including the partition wall portion **132** is larger than the frequency of the motor rotor **11** that operates at the maximum rotation speed.

[0041] The motor stator **12** is accommodated in the motor housing **2**. The motor stator **12** surrounds the motor rotor **11** in the circumferential direction. The motor stator **12** includes a plurality of coils and a plurality of iron cores. When an electric current is supplied to the coils and the motor stator **12** generates a magnetic field, a circumferential force acts on the motor rotor **11** due to the magnetic field, and as a result, torque is applied to the shaft **6**. A driving source of the electric motor **10** is a battery of a vehicle or the like. The electric motor **10** may regeneratively generate electric power using rotational energy of the motor rotor **11** during deceleration of the vehicle. The electric motor **10** has characteristics that allow the electric motor **10** to cope with the high-speed rotation (for example, 100,000 to 200,000 rpm) of the motor rotor **11**.

[0042] As described above, in the motor rotor **11**, the first shaft **61** is inserted into the one side of the holding portion **131**, the second shaft **62** is inserted into the other side of the holding portion **131**, and the permanent magnets **14** are provided between the first shaft **61** and the second shaft **62** inside the holding portion **131**. Accordingly, for example, compared to the case where the permanent magnets are disposed on an outer periphery of the shaft **6**, miniaturization of the motor rotor **11** can be achieved. Moreover, the partition wall portion **132** is provided between the first shaft **61** and the second shaft **62**. According to the partition wall portion **132**, deformation of the holding portion **131** can be suppressed, and a decrease in the rigidity of the holding portion **131** can be suppressed. Further, the partition wall portion **132** forms the motor rotor **11** which is a rigid body, together with the holding portion **131**, the first shaft **61**, and the second shaft **62**. Accordingly, a decrease in the bending rigidity of the motor rotor **11** can be suppressed, and a decrease in the natural frequency of the motor rotor **11** can be suppressed. Therefore, in the rotation range of the motor rotor **11** (the range of rotation speed of the motor rotor **11**), the frequency of the motor rotor **11** can be prevented from reaching the natural frequency of the motor rotor **11**, and the occurrence of resonance in the motor rotor **11** can be suppressed. In other words, the critical speed range (rotation range) of the motor rotor **11** can be improved.

[0043] The partition wall portion **132** is provided between the plurality of permanent magnets **14**. Accordingly, the degree of freedom in designing each of the plurality of permanent magnets **14** and the partition wall portion **132** can be improved. For example, the flexibility of the disposition of each of the permanent magnets **14** and the partition wall portion **132** can be improved.

[0044] The rigidity of the partition wall portion **132** is larger than the rigidity of each of the permanent magnets **14**. Accordingly, a decrease in the rigidity of the motor rotor **11** can be reliably suppressed.

[0045] Each of the holding portion **131** and the partition wall portion **132** is a part of the holding member **13**. Namely, the holding portion **131** and the partition wall portion **132** are seamlessly formed as an integral member. Alternatively, the holding portion **131** and the partition wall portion **132** may be connected and integrated via a connecting portion. The connection referred to here is not particularly limited as long as the connection is a known method for connecting two members, such as welding. Accordingly, the cost can be reduced and the productivity can be improved by reducing the number of components.

[0046] The first shaft **61** is press-fitted into the one side of the holding portion **131**, and the second shaft **62** is press-fitted into the other side of the holding portion **131**. The partition wall portion **132** is provided between the two permanent magnets **14**. Accordingly, a decrease in the rigidity of the motor rotor **11** can be more reliably suppressed.

[0047] According to the turbocharger **1**, as described above, a decrease in the rigidity of the motor rotor **11** can be suppressed.

[0048] One embodiment of the present disclosure has been described above, however, the present disclosure is not limited to the above-described embodiment.

[0049] For example, the example in which each of the holding portion **131** and the partition wall portion **132** is a part of the holding member **13** has been described, however, as shown in FIG. **3**, the partition wall portion **132** may be formed separately from the holding portion **131**. Accordingly, the degree of freedom in designing each of the holding portion **131** and the partition wall portion **132** can be improved. For example, the partition wall portion **132** may be press-fitted into the holding portion **131**. For example, the partition wall portion **132** may be connected to the holding portion **131** by welding or the like. The material of the partition wall portion **132** may be different from the material of the holding portion **131**.

[0050] The example in which the partition wall portion **132** is provided between the two permanent magnets **14** has been described, however, as shown in FIG. **4**, the partition wall portion **132** may not be provided between the two permanent magnets **14**. The partition wall portions **132** may be each provided between the first shaft **61** and one permanent magnet **14** and between the second shaft **62** and the other permanent magnet **14**. Namely, the magnet may not be interposed between the second shaft **62** and the partition wall portion **132** located on a second shaft **62** side out of two partition wall portions **132** arranged in the axial direction of the shaft **6**. Accordingly, a decrease in the rigidity of the motor rotor **11** can be suppressed with a simple configuration. In this case, one partition wall portion **132** is in contact with each of the first shaft **61** and the one permanent magnet **14**. The other partition wall portion **132** is in contact with each of the second shaft **62** and the other permanent magnet **14**. The permanent magnets **14** are in contact with each other. Each of the partition wall portions **132** is formed separately from the holding portion **131**. In addition, in this case, the plurality of permanent magnets **14** may be integrated. Namely, the motor rotor **11** may include one permanent magnet. In addition, the partition wall portion **132** may not be provided in one of a location between the first shaft **61** and the one permanent magnet **14** and a location between the second shaft **62** and the other permanent magnet **14**. Namely, the partition wall portion **132** may be provided between at least one of the first shaft **61** and the second shaft **62** and the permanent magnet **14**.

[0051] The position of the partition wall portion **132** may be appropriately determined based on various factors such as a mass distribution and an elastic modulus of the motor rotor **11** and a rotation speed of the motor rotor **11** etc.

[0052] The motor rotor **11** may include three or more permanent magnets **14**. In this case, the partition wall portion **132** may be provided between at least a pair of the permanent magnets **14** adjacent to each other.

[0053] A through-hole or the like may be formed in the partition wall portion **132**. The partition wall portion **132** may have, for example, an annular shape.

1. A motor rotor comprising:

a holding member which is provided between a first end of a motor housing and a second end of the motor housing;

a first shaft which is provided between the first end of the motor housing and the holding member, and which is inserted into a first opening of the holding member;

a second shaft which is provided between the holding member and the second end of the motor housing, and which is inserted into a second opening of the holding member; and

a magnet member provided between the first shaft and the second shaft in the holding member.

2. The motor rotor according to claim **1**,

wherein the holding member comprises:

a holding portion having a tubular shape and comprising the first opening and the second opening; and

a partition wall portion provided between the first opening and the second opening in the holding portion.

3. The motor rotor according to claim **2**,

wherein the partition wall portion is located at approximately a center of the holding portion in an axial direction.

4. The motor rotor according to claim **2**,

wherein the first shaft is press-fitted into the first opening of the holding portion, and

wherein the second shaft is press-fitted into the second opening of the holding portion.

5. The motor rotor according to claim **2**,

wherein the magnet member is press-fitted into the holding portion.

6. The motor rotor according to claim **2**,

wherein the magnet member comprises:

a first magnet provided between the first shaft and the partition wall portion in the holding portion; and

a second magnet provided between the partition wall portion and the second shaft in the holding portion.

7. The motor rotor according to claim **2**,

wherein the partition wall portion is provided between the first shaft and the magnet member in the holding portion.

8. The motor rotor according to claim **2**,

wherein the partition wall portion is provided between the magnet member and the second shaft in the holding portion.

9. The motor rotor according to claim **2**,

wherein the partition wall portion comprises:

a first partition wall portion provided between the first shaft and the magnet member in the holding portion; and

a second partition wall portion provided between the magnet member and the second shaft in the holding portion.

10. The motor rotor according to claim **9**,

wherein the magnet member comprises:

a first magnet provided between the first partition wall portion and the second partition wall portion; and

a second magnet provided between the first magnet and the second partition wall portion.

11. The motor rotor according to claim **2**,

wherein a rigidity of the partition wall portion is larger than a rigidity of the magnet member.

12. The motor rotor according to claim **2**,

wherein an elastic modulus of the partition wall portion is larger than an elastic modulus of the magnet member.

13. The motor rotor according to claim **2**,

wherein the holding portion and the partition wall portion are formed integrally so as to form a single integral member.

14. The motor rotor according to claim **13**,

wherein a material of the single integral member is a non-magnetic metal.

15. The motor rotor according to claim **13**,

wherein a natural frequency of the motor rotor is larger than a frequency of the motor rotor when the motor rotor operates at a maximum rotation speed.

16. The motor rotor according to claim **2**,

wherein the holding portion and the partition wall portion are formed separately.

17. The motor rotor according to claim **16**,

wherein the partition wall portion is press-fitted into the holding portion.

18. The motor rotor according to claim **2**,

wherein the partition wall portion comprises a through-hole.

19. A turbocharger comprising:

a turbine impeller;

a compressor impeller;

a holding member which is provided between the turbine impeller and the compressor impeller;

a first shaft which is provided between the turbine impeller and the holding member, and which is inserted into a first opening of the holding member;

a second shaft which is provided between the holding member and the compressor impeller, and which is inserted into a second opening of the holding member; and

a magnet member provided between the first shaft and the second shaft in the holding member.

20. The turbocharger according to claim **19**,

wherein the holding member comprises:

a holding portion having a tubular shape and comprising the first opening and the second opening; and

a partition wall portion provided between the first opening and the second opening in the holding portion.

* * * * *